SOME OBSERVATIONS On the USE of BROAD WHEELS; WITH A PROPOSAL FOR A MORE GENERAL AMENDMENT OF THE ROADS.

LONDON:
Printed in the YEAR 1765.

SOME

OBSERVATIONS

On the USE of

BROAD WHEELS, &c.

AS nothing contributes more to the general honour and commercial intereſts of a kingdom, or to the particular health, pleaſure and ſatisfaction, of every individual inhabitant, than the improvement of its public roads; ſo nothing can therefore better merit the ſeaſonable attention and interpoſition of the Legiſlature, without which ſuch improvement will perhaps be ſcarce attempted, will certainly never be compleated. The introduction of *Broad Wheels*, has proved the moſt effectual meaſure hitherto deviſed, for the benefit and amendment of our public roads; the ſalutary effects hereby produced are felt and acknowledged in all parts of this kingdom, but *not in each equally*, for reaſons which I ſhall aſſign in the ſequel. This ſcheme, though ſtrenuouſly oppoſed by the prejudices of cuſtom, the general obſtinacy of man-

kind, and the univerſal averſion of the lower ranks of people to every thing *new*, has, by the public ſpirit and perſeverance of a ſet of gentlemen, endued with more liberal principles, and under the patronage of a young nobleman of diſtinguiſhed merit, been at laſt happily eſtabliſhed in law, and that law has been *pretty well* carried into execution.

The principal northern roads, I am told, are ſo much improved, and ſo well preſerved by the uſe of *Broad Wheels*, as now directed by the wiſdom of parliament, that no alteration in the conſtruction of our Broad Wheel carriages ſeems *abſolutely neceſſary* to *thoſe* roads; but I can ſafely aver, from my own obſervation, that in the *public roads* within the counties of Devon, Somerſet, Dorſet, Wilts, Hants, Glouceſter, Berks, Oxford, Bucks, Northampton, Warwick, and Worceſter, there appears a very viſible neceſſity of an immediate alteration and amendment of the laws regulating the *dimenſion* and *ſituation* of Broad Wheels.

This difference of effects produced by the preſent uſe of Broad Wheels on the *principal northern roads*, and *within the above named counties*, ſeems to ariſe from theſe cauſes, viz. in the *northern counties* the general ſtratum is much ſtronger, the ſtone and gravel pits more commodiouſly ſituated, and the turnpike revenues larger. The bad condition of our *ſouthern roads* is not however to be imputed to the *breadth*, but rather to the *narrowneſs* of the Wheels now preſcribed by law, which cut deep

ruts

ruts or tracks *nine inches* wide, and *four feet four inches* distant: each of these tracks is so narrow, that a saddle horse can neither trot or gallop in it, without endangering his own legs and his rider's neck; coach horses cannot trot, nor even waggon horses walk, in this narrow track, and partly compelled by the *narrowness* of the tracks, and partly by their *inconvenient distance*, are alternately jumping from the track upon the bank within it, and tumbling into the track again; and whilst the wheels on one side of the coach are running in one track, the opposite wheels are grinding on the inner edge of the other; whereby the coach has a very disagreeable and sometimes dangerous inclination; a considerable part of the horse's force is consumed by the unsteadiness as well as obliquity of the draught; the wheels and harness are much distended and strained, often broken, and always sooner worn out.

For the better explanation of what is herein said of the *present*, and of the *proposed distances* of the ruts, it is necessary to observe, that though the present Broad Wheel Act permits the distance of the wheels to be *five feet six inches*, from the middle of the fellies on one side, to the middle of the fellies on the other side, whence the outer edges of the two ruts might have been *six feet three inches*; yet, by the practice which now prevails, the wheels are so placed, that the said outer edges are only *five feet ten inches* distant.

As this act expires in June 1765, this is the *proper ſeaſon* for preparing and enacting a new law, which may commence at the expiration of the preſent, and remove ſuch defects and inconveniences therein, as time and experience have pointed out: The remedy which I preſume to offer the public for the evils complained of is obvious, very practicable, and, if applied, will certainly prove effectual. *Let the breadth of future wheels be ſix inches, and the hind axle be made one foot ſhorter than the fore axle, ſo that the hind wheels then running juſt within the track of the fore wheels, may together with them, make one track of twelve inches on each ſide, and let the length of the axles be ſuch that the outer edges of the tracks may be juſt ſix feet diſtant, and the inner four.* This method of conſtruction will at once totally remove all the before-mentioned inconveniences, the ruts will be at their proper diſtance, and of a breadth ſufficient for all purpoſes. Many other advantages will attend the propoſed alteration of the wheels and axles, which I ſhall recite after having firſt ſtated and anſwered the only objections I have heard to this plan, though frequently mentioned in converſation during the laſt three or four years.

One objection is, that the *additional breadth* of the track will *proportionably encreaſe* the *friction:* Another is, that the hind wheels paſſing over a *different* ſurface from the fore wheels, will not paſs ſo eaſily as they would following in a line over the *ſame* ſurface. The former argu-

argument is indeed oppoſed to *Broad Wheels* in general, but it is founded on erroneous and exploded principles; for by the doctrine now generally received, and which ſeems (at leaſt in the caſe of wheel carriages) ſufficiently demonſtrated by theorems, and fully confirmed by experiments, we are taught that *friction* is *not* encreaſed by the magnitude of ſurfaces rubbing each other; that with obſtacles of equal height, *friction* is proportioned to the *weight* only; and that the *power* required is proportioned to the *height* of the obſtacle, and by no means to the *length* of it. In Monſ. de la Hire, Dr. Helſham, and other *modern* writers on the doctrine of *friction*, many *demonſtrations* and *experiments*, proving (contrary to the opinions of their predeceſſors) the truth of what I have advanced, may be found by the curious reader: However, I will endeavour to explain and ſupport this *doctrine* by an argument or two, which I do not remember to have met with in theſe authors, as they are very eaſy to be conceived, and as eaſy (if doubted) to be proved by experiment.

Let an obſtacle, conſiſting of *nine pieces* of iron, each one inch cubical and firmly united, be ſo placed, that a *nine inch wheel* may be drawn over it, each inch of the wheel equally preſſing its *correſpondent* inch of the obſtacle, and let the *firſt experiment* be now made: for a *ſecond experiment*, let *ſix* of the *nine* iron blocks be removed, leaving the two outſide and the middle; for a *third experiment*, let the *middle* block

block alſo be removed. In each of theſe experiments the *ſum of the friction*, and the *power* neceſſary to draw the wheel over the obſtacle, will prove exactly the ſame; for in the firſt caſe, each inch will receive $\frac{1}{9}$, in the ſecond $\frac{1}{3}$, and in the laſt $\frac{1}{2}$ of the *whole friction*, as it does of the *whole weight*, without which it cannot exiſt, and to which it muſt always be proportional. Or take two boards or books, whoſe ſurfaces are *equally ſmooth*, one of which contains *twice* as many ſuperficial inches as the other, faſten them together, and place them on a table with the *leſſer board undermoſt*; with a ſtring fixed to theſe boards, and a ſufficient weight ſuſpended thereby over the edge of the table, draw the boards very gently on the ſurface of the table, then turn the boards, and let the *larger* be next the table, and by repeating the experiment you will find the *ſame* weight ſtill ſufficient to draw the boards or books, though the *magnitude* of the ſurface rubbed, is *doubled*.

From what I have ſaid, I hope it appears, that the *former objection* ought not to prevail againſt the *general* uſe of broad wheels; and when raiſed againſt the plan now recommended, it is quite *abſurd*, being founded on a falſe ſuppoſition of an encreaſed magnitude of ſurface, and proving on the wrong ſide of the queſtion, if it proves any thing; for the *quantity* of the ſurface rubbed is not to be meaſured by the *breadth* of the tracks, but by the *ſum* of the ſurfaces preſſed by *all four* wheels, which, as they

they are now uſed, amounts to *thirty-ſix* inches, and if altered, as I propoſe, would amount only to *twenty-four* inches; ſo that according to this doctrine of friction, one *third* of the preſent friction would be taken off.

In anſwer to the other objection, I admit that (as one inch of each bank, on the outſide of the preſent nine-inch ruts, and two inches of each bank within the ſaid ruts, muſt be taken or worn down, in order to bring the ruts to the propoſed *breadth and diſtance*) the firſt two or three carriages will be hereby retarded, but ſuch retardation cannot, in a well frequented road, laſt *twenty-four* hours: for the fore-wheels and hind-wheels of *ſucceſſive* carriages, following *reſpectively* in a line over the *ſame* ſurface, will ſoon wear the *whole twelve-inch* track as ſmooth as the *nine-inch* track now is, but not ſo deep; becauſe the annual preſſure of weights, now ſupported by nine inches, will then be ſupported by twelve, ſo that *ſuch* preſſure on each inch will be reduced one quarter, and the friction of ſix-inch wheels will be *ſomewhat leſs*, becauſe theſe wheels will be lighter than the nine-inch wheels: I would be here underſtood as ſpeaking of our *Turnpike* Roads, the preſervation of which appears to be the ſole object of our Broad-wheel laws; for over ploughed land, or other ſuch ſurface, wherein the obſtacles are not to be *ſurmounted* but only *depreſſed*, the hind-wheel will certainly follow more eaſily in the *ſame track*, becauſe it has no freſh obſtacles to *depreſs*; but wherever the

the obſtacles are to be ſurmounted and not depreſſed, the hind-wheel will follow in the manner propoſed with equal eaſe.

To explain and prove this argument, let a ſtone or piece of timber of a proper length and given thickneſs, be fixed acroſs any hard road, ſo that it cannot be depreſſed, the hind-wheel having exactly the ſame obſtacle to *ſurmount*, whether it follows in the ſame track or in the ſame manner propoſed, muſt follow with the *ſame eaſe*; but a ſix-inch wheel will, in either ſituation, follow *ſomewhat more* eaſily, not becauſe *thinner*, but becauſe *lighter* than a nine-inch wheel: And our turnpike-roads conſiſt, and muſt conſiſt, of obſtacles of the ſurmountable ſort, and not of the depreſſible; the *latter* ſort being depreſſed by the firſt heavy carriage, and the *former* ſort only remaining to obſtruct ſucceeding carriages: the greateſt difficulty which our waggoners encounter on the road, is the aſcent of a ſteep hill, which is, in fact, an infinite ſeries of ſtone ſteps to be ſucceſſively *ſurmounted* by the wheels of the waggon drawn thereon.

The *friction* which ariſes from the box of the wheel running round its axis, cannot poſſibly be *encreaſed*, becauſe the diameters of the wheels and axis remain the ſame, and conſequently their velocities. But thoſe gentlemen who think that the *magnitude* of ſurfaces will *encreaſe* their friction, muſt admit that the wheel I contend for, being *thinner*, muſt have *leſs* friction of this ſort.

There

There is a third ſort of *friction* ariſing from the contact of the ſides of the felly with the banks of the ruts in which the wheel runs, *one half* of which friction muſt evidently be removed by the propoſed ſituation of the wheels; for the inner ſides of the fore-wheels, and outſides of the hind-wheels, will have *no* contact, and, conſequently, *no* friction, with the bank of the rut: this ſituation of the wheels will alſo be attended with another advantage. In flat roads, the ruts are generally filled with mud, and the *reſiſtance* of this ſtiff, heavy fluid, greatly obſtructs the preſent Broad-wheel, becauſe it fills the rut, ſo that the mud cannot well paſs by it; but this reſiſtance will be much diminiſhed by the wheels now recommended; for the mud will eaſily paſs in *one* half of the twelve-inch rut, whilſt the wheel does in the *other*.

Having now fully anſwered the only objections I have ever heard to this plan, I think it neceſſary to remove the *prejudices* which ſome of my readers may probably have entertained againſt it, from the fate of the experiments made laſt year with Mr. *Bourne*'s *machine*, by explaining the reaſon of his diſappointment. The beſt modern writers on mechanical ſubjects eſtabliſh and demonſtrate this law: as the radius of a wheel is decreaſed, the power required to *draw* it muſt be encreaſed, the powers required being inverſely as the ſquare roots of the radii. By Mr. Bourne's pamphlet, I find his wheels were but twenty-four inches diameter, and the fore-

fore-wheels of a common waggon are fifty-seven. Now, as 5 is greater than the ſquare root of 24, and 7,5, is leſs than the ſquare root of 57; and ſince two is to 3 as 5 to 7,5, it neceſſarily follows, that *two horſes* can draw a greater weight with wheels of a common diameter, *cæteris paribus*, than *three ſuch horſes* can with wheels as low as thoſe of Mr. *Bourne*'s *machine*.

The principal inconveniencies attending the preſent uſe of *nine-inch* wheels might indeed be removed by *twelve-inch* wheels following in the *ſame* track; but there are many reaſons which induce me to give a preference to the *ſix-inch* wheels placed as hereby propoſed: and among others the following, viz. A ſet of ſix-inch wheels will be at leaſt *twelve pounds cheaper* than twelve-inch, and *ſeven pounds cheaper* than nine-inch wheels; the nine-inch fellies frequently ſplit and ſeparate in two parts, to which accident the *twelve-inch* would be much more liable, and the *ſix-inch* fellies much leſs; a ſet of ſix-inch wheels will be at leaſt *half a ton* lighter than one of twelve-inch wheels, and will turn much more eaſily; and as already obſerved, and I hope proved, the uſe of ſix-inch wheels will be attended with *ſomewhat leſs friction* than that of broader wheels: for the benefit of the owners of *nine-inch* wheels not worn out at the expiration of the preſent act, a clauſe may be inſerted in the next, to enable them to uſe thoſe wheels, letting out their fore-wheels *one inch each*, and taking in their

hind

hind wheels *two inches each*, the expence of which would be very trifling: moreover, if there are thoſe who think that *twelve-inch* wheels following in the ſame track would be preferable, the uſe of theſe likewiſe may be permitted by the act, and the ſame indulgencies and exemptions granted to all three ſorts, which all running in the *ſame track* will not obſtruct each other, or do the road any conſiderable damage; but the two broader ſorts will do their owners ſo much damage, by their extraordinary expence and other inconveniencies, as will ſoon compel them to the uſe of the *ſix-inch wheels*; and within two years from the commencement of the act propoſed, no other wheels but of the latter ſort, entitled to exemptions, will be ſeen on our public roads.

But, whatever ſort of wheels prevails, our roads will never be much improved, without a *proper limitation* of the weight to be carried in all heavy carriages, for the ſurface of our roads is a kind of artificial incruſtation over bogs and marſhes, at a vaſt expence, and much reſembling a ſheet of ice extended over a river, which would bear a thouſand waggons of a limited weight ſucceſſively, but would be broken by a ſingle waggon with one very heavy load, and rendered impaſſable for all others. The immediate injury done the roads by the *exceſſive weight* now carried in the broad-wheel waggons, is not the only miſchievous effect of that weight, another *conſequential* miſchief, equally detrimental to the roads, is the *diminution of the*

Toll,

Toll, ſo reduced hereby; and by the indulgence given broad-wheels by the Legiſlature, that the whole revenues of many turnpikes, though aſſiſted by a clauſe in the laſt wheel act, are not ſufficient to keep the roads in any tolerable repair: the broad-wheel waggons ſeldom carry leſs than *ſix ton*, and the narrow are reſtrained by law to *two ton*, the former therefore carry three *ſuch* loads as the latter, and yet pay but ſixpence for theſe three loads, viz. *two pence* each load, where the narrow-wheeled waggons pay *eighteen pence*.

The moſt *favoured wheels* ſhould therefore, in my opinion, be limited to or under *five ton*, waggon included, and the Commiſſioners of turnpikes, whoſe revenues will ſupport the expence of weighing machines, ſhould be compelled to erect them, under ſevere penalties; but, as theſe machines are too expenſive for ſome turnpikes, whoſe revenues are ſmall, and there ſeems to be no other commodious method of *reſtraint*, but a *farther limitation* of the number of horſes; that number ſhould, in my opinion, be reduced to *ſix*, when diſtant twenty miles from any ſuch machine erected on that road in which they are travelling. By theſe regulations the roads would be much preſerved, and the toll ſo augmented as to become ſufficient for the neceſſary repairs.

In order to prove, as well by experiment as argument, the utility of my plan, I procured a ſmall model of my propoſed waggon, with two ſets of wheels, which could be with eaſe alternately

lately fixed thereto, one ſet proportioned to ſix inch wheels, and placed as propoſed by my plan, the other ſet proportioned to nine inch wheels, and following as they do; with this model I made ſeveral experiments, a table of which was inſerted laſt winter in the London Chronicle, and ſhows, that with either ſett of wheels the ſame weight requires nearly the ſame power. Encouraged by theſe experiments, and the advice of a particular friend, I have ſince conſtructed the waggon itſelf, with which I have made the following tryals:

Dec. 23, 1764. In Blenheim park, by the permiſſion of the noble proprietor of that delightful place, who, with his accuſtomed generoſity and public ſpirit, ordered his ſervants to attend with a broad-wheel waggon and eight horſes for that purpoſe, the firſt tryal was made: the two waggons were each loaded with three tons and an half, and the horſes divided into two teams, alternately drawing both waggons, and driven by his Grace's drivers; and though the ſpectators had conceived ſtrong prejudices againſt the new waggon, yet they were all convinced (as I am informed) that it was drawn with ſomewhat greater eaſe than the broad-wheel waggon.

Jan. 14, 1765. This waggon was tried againſt another broad-wheel waggon, loaded with three ton, and drawn by the ſame number of horſes, changed alternately as in the firſt tryal, but partly over boggy and ploughed land; when the ſpectators thought the new waggon drawn with

with rather more eaſe over the ſound road and dry turf, and with leſs eaſe over the boggy and ploughed land; the reaſon of which I have herein before ſtated.

Jan. 19, 1765. This waggon was tried a third time, in the manner following: it was loaded with two ton twelve hundred, which, with the waggon geers, &c. amounted to about *four* ton, and was drawn on the turnpike road between Brackley and Buckingham, with great eaſe, by *four* horſes, *ſix miles* and about three hundred yards, within two hours and thirty-five minutes, though ſtopt ſeveral times by uſual accidents; the horſes were of the coaching kind, much inferior in uſe, ſize, and ſtrength, to waggon-horſes, and the road very bad.

The proprietor will engage to draw five tun in this waggon (the ſaid waggon included) to London, with only ſix horſes (if this can be deemed a proof of its utility) and thinks the obſtruction ariſing from the preſent narrowneſs of the ruts at leaſt equal to another ton.

A. B.